CASE REPORT

Upper Arm Compartment Syndrome: A Case Report and Review of the Literature

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Although rare, acute compartment syndromes of the upper arm exist and are severe complications of trauma or after orthopedic, vascular, or other surgery of the limbs. Most common are the compartment syndromes of the lower arm and lower leg. An upper leg compartment syndrome occurs less frequently and a compartment syndrome of the upper arm is even less common. In this article a case of a compartment syndrome of the upper arm following a minor trauma in a patient using anticoagulants, is presented. A systematic review of the available literature and important recommendations will be discussed.

Case Report

An 84-year-old woman was seen at the emergency department with severe pain at the right upper arm of one day duration. A week before, she suffered a minor hit to the upper arm and developed a hematoma at the anterior side of the upper arm. At that moment she had no pain or any other complaints. At day 6 post-trauma, however, she developed a large swelling and severe pain at the anterior side of the upper arm. No new trauma was reported. Pain medication was insufficient. Due to logistical problems, she went to the emergency department the day after she developed these complaints. Clinical investigation of the right arm showed a large new hematoma at the anterior side of her right upper arm. She had a drop hand (Fig. 1), disability to flex all fingers and total loss of sensibility in the right hand (no reaction to needle prick) and diminished sensibility of the rest of the lower arm. Active flexion and passive extension of the elbow were very painful. There were normal pulsations of the ulnar and radial artery. An ultrasound of the upper arm showed a large hematoma (4 cm × 5 cm × 20 cm) in the bicep muscle. Because of the use of fenprocoumon (Marcoumar, Meda Pharma n.v., Brussels,

Belgium), the activated coagulation time of whole blood (aPTT) and international normalized ratio (INR) were controlled. Both aPTT and INR were too disturbed to determine.

Because of a high suspicion of a compartment syndrome, we restored the coagulation levels using prothrombin-converting factor. The patient was brought to the operating room. Using an antero-lateral incision, we performed a total fasciotomy of the anterior compartment. A total of 200 ml of blood was evacuated. The bicep muscle started bleeding a couple of minutes later. We exposed the radial nerve which was only minimally vital. Stimulation of the nerve showed no contractions of muscles distally. To be sure there was no compartment syndrome of the posterior compartment, we also performed a total fasciotomy of the posterior compartment. Two drains (one anterior and one posterior) were used. Primary wound closure was possible (Fig. 2).

One day postoperatively, she had a normal sensibility in the lower arm, an increase in sensibility in the whole hand and she was able to flex the fingers (not yet with full strength). She still suffered a drop hand, not having any contractions of the extensors of the wrist and hand.

At the out-patient consultation 3 months later, no further improvement of the motor function was detected. She still had a drop hand, but the flexion strength of the fingers and sensibility of the hand were normal.

Discussion

Compartment syndrome is a limb-threatening and life-threatening condition. Untreated, increased levels of pressure in compartment can lead to tissue necrosis, permanent functional impairment and possible renal failure and death due to acute rhabdomyolysis^{1,2}. It is a painful condition that is caused by an elevation of pressure within a fibro-osseous space resulting in decreased tissue perfusion^{1,2}. The initial rise in

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Fig. 1 Drop hand preoperatively.

intracompartmental pressure causes increased extravascular venous pressure. Because of the lack of musculature in the wall media, this relatively small rise in pressure causes the venule walls to collapse. The resulting decrease in hydrostatic gradient causes reduced local perfusion and increased interstitial pressure. This increased interstitial pressure in turn causes increased edema within the compartment, and this cascade of events repeats itself perpetually. Vasospasm and shock lead to decreased arteriolar pressure and possibly closure of end arterioles, leading to a further decrease in tissue perfusion. Ischemia occurs when a critical threshold is reached in the local arteriovenous gradient and when circulation is compromised to the point that blood flow is insufficient to meet the metabolic demands of the tissue.

Compartment syndrome of the lower limb and forearm is a well-known pathology and it is most common in the anterior and deep compartments of the leg and the volar compartment of the forearm. It can be divided into acute, sub-acute, and chronic compartment syndrome. Common causes of acute compartment syndrome are fractures, hemorrhage, vascular puncture, compression of the limb, crush injuries, and burns. Factors associated with an increased risk of compartment syndrome include medical comorbidities associated with abnormal bleeding diatheses, volume resuscitation, altered mental status, or neurologic compromise³. Acute compartment syndrome is seen more often in patients under 35 years of age. Young men appear to have the highest incidence. This may be explained by the relatively larger muscle mass of men contained within fascial compartments that do not change in size once growth is complete. McQueen *et al.* analyzed 164 patients with traumatic acute compartment syndrome. In 69% of cases, compartment syndrome was associated with fracture. Soft-tissue injury without fracture was the second most common cause of injury (23.2%)³. Chronic compartment syndrome typically affects young people who are engaged in endurance sports. The primary clinical feature is a sensation of

tightness or aching pain in a defined compartment of the affected limb, starting during activity or hours after activity ceases and lasting for varying lengths of time⁴.

There are classically five P's associated with compartment syndrome: pain, paresthesia, pallor, paralysis, and pulselessness. Sometimes a sixth P for poikilothermia is added^{1,2}. The earliest symptoms are pain out of proportion and pain with passive stretching of the muscles. Pulselessness is rare and only occurs after arterial injury. Matsen *et al.* described consistent progression of neurological dysfunction associated with compartment syndrome⁵. A typical sequence of diminished subjective light touch followed by hypoesthesia, after which progressive motor weakness and anesthesia are observed. Compartment syndrome must be suspected with tense, swollen compartments and a history of injury.

Mostly the diagnosis is made clinically, however, in some cases it can be useful to measure the intracompartmental pressure. Great debate exists within the literature regarding the most reliable method for measuring compartment pressure. Also the absolute interstitial tissue pressure that represents the diagnosis of compartment syndrome is still a point of discussion. Values proposed range from 30 to 50 mm Hg referenced as being an indication for fasciotomy. Whitesides *et al.* suggest that a difference between diastolic blood pressure and the compartment of ≤ 20 mm Hg or a difference between mean arterial pressure and the compartment of ≤ 30 mm Hg indicates a compartment syndrome⁶.

The upper arm contains three compartments: a flexor (volar) and extensor (dorsal) compartment and the deltoid compartment^{1,7}. The deltoid compartment is surrounded by the deltoid fascia and splits into two parts. The deltoid is innervated by the axillary nerve. The anterior and posterior compartment are divided by the medial and lateral intermuscular septa and the humerus. The brachial fascia is a dense fibrous sheath that surrounds the muscles in each compartment. The

Fig. 2 Surgical wound antero-lateral for the fasciotomy of the anterior compartment.

anterior compartment includes the musculi biceps brachii, brachialis, and coracobrachialis and is supplied by the artery brachialis and innervated by the nervus musculocutaneus. The median, ulnar, radial, medial antebrachial cutaneous, and lateral antebrachial cutaneous nerves all course distally in the anterior compartment. The posterior compartment contains the musculus triceps brachii and is supplied by the artery profunda brachii and innervated by the nervus radialis. Although ulnar, the posterior antebrachial cutaneous nerve and the nerve to the musculus anconeus cross the posterior compartment.

The mean goal in the treatment of acute compartment syndrome is decompression of all affected nerves and vessels⁵. Decompression of the upper arm is possible through a single medial or lateral incision. Medial skin incision must be considered when vascular revision is needed, lateral when an osteosynthesis has to be performed. In some cases it is necessary to extend the exposure distally into the lower arm or proximally to the deltoid. Anteriorly, the brachial artery should be explored to release its fascial envelope if necessary. Only in rare cases, both compartments are involved. After performing the fasciotomy, wounds are left open when necessary. If left open, a second operation is often performed after 48 to 72 h for further debridement and irrigation. Delayed primary wound closure can be done at the same time. Various other techniques and devices have been proposed to increase the rate of skin closure and reduce the need for skin grafting such as intracutaneous skin sutures, stretching, and mechanical closing.

The outcome after compartment syndrome depends on different criteria like severity, duration of the ischemia, and comorbidities². Time from diagnosis to fasciotomy is the most important factor. After performing a fasciotomy, mortality rates of 11% to 15%, amputation rates of 11% to 21%, and serious morbidity have been reported⁷⁻⁹. Animal models show that irreversible injury to muscles and nerves occurs after 8 h of ischemia. Delay beyond 6 to 24 h may result in Volkmann ischemic contracture, neurologic deficit, infection, amputation, or death^{1,8}.

Review of the Literature

The following databases were searched: Medline (January 1966 to April 2011), Cochrane Database of Systematic Reviews (January 1988 to April 2011), Cochrane Clinical Trial Register (January 1988 to April 2011), and Embase (January 1988 to April 2011). The key word terms "compartment syndrome" and "upper arm" were used. The inclusion criteria were original articles reporting acute cases of upper arm compartment syndrome. 268 articles were found using this search criteria. After screening the abstracts, 22 full-text articles were assessed for their eligibility and eventually 13 articles were included in the quantitative synthesis. All these 13 articles just reported cases of upper arm compartment syndrome. None of these give an overview of the available literature.

Traumatic

Two case reports have been published of an upper arm compartment syndrome following biceps tendon rupture and

anticoagulants^{10,11}. One presents a 77-year-old man on warfarin who reported injuring his right shoulder while playing tennis¹⁰. The diagnosis of biceps tendon rupture was made. One case report showed a patient, who was found unconscious after binge drinking¹², and another a 40-year-old man, who collapsed and compressed his arm between the floor and his thoracic cage¹³. Examples of post-traumatic cases are a high school athlete¹⁴, a biker who fell on his arm¹⁵, a power-lifter¹⁶, a 79-year old¹⁷, a 34-year old¹⁵ and a 48-year old man¹⁸, who all consulted the emergency room with swelling and pain after contusion of the upper arm. Another patient had a compartment syndrome with a fracture of the humerus¹⁹. This case report showed a 46-year old man after fractures of the lower limbs²⁰. Due to extravasation of the fluids infused under pressure, a compartment syndrome of the upper arm occurred a few hours later.

Non-traumatic

A non-traumatic case occurred in a twenty-nine-year-old healthy woman who underwent surgery on her hand²¹. A tourniquet was placed around the middle of the upper arm. Twelve hours after surgery, the patient complained of pain and swelling. A similar case was presented in a 29-year old woman who was given a non-invasive blood pressure cuff during operation²². After surgery swelling and pain occurred in her upper arm. The diagnosis of acute compartment syndrome was made. A rare case was that of a patient receiving an injection of epoetin in the shoulder²³. In the next two days she developed an increasing swelling and pain. The diagnosis of a posterior compartment syndrome of the upper arm was made clinically and the intracompartmental pressure was 93 mm Hg. In all these cases a fasciotomy was performed. Another case presented a three-month-old male infant who had hemophilia and a venipuncture caused a compartment syndrome²⁴.

Only four patients with a solitary anterior compartment syndrome are reported in literature. Two of those after trauma (bicep tendon rupture)^{10,11} one after malpositioning of a blood pressure cuff²² and one with a pre-existing condition (hemophilia) and having a venipuncture²⁴. In the biceps tendon rupture cases the diagnosis was made clinically and the anterior compartment was only released during an open procedure. In the other solitary anterior compartment syndrome cases the diagnosis was made using intracompartmental pressure measurement. However, in the case of the malpositioning of the pressure cuff, an open procedure was performed releasing both the anterior and posterior compartment. In the case of the patient with hemophilia, factor VIII concentrate was administered without performing a release of the compartment.

Conclusion

An acute compartment syndrome of the upper arm is rare, but should be recognized because it is a limb- and life-threatening condition. As mentioned, there are several causes of compartment syndrome of the upper extremities. There are

not only traumatic causes but also non-traumatic. In the literature we found non-traumatic cases of a upper arm compartment syndrome after an infiltration of the shoulder, using a tourniquet at the upper arm, due to extravasation of fluids infused under pressure, and after an venipuncture. Because of the limb-threatening and even life-threatening conditions this often results in a complex decision-making process regarding its diagnosis and management^{1,2}. The possibility of an acute compartment syndrome should certainly be considered in patients with acute pain, swelling, and a history of injury. An

early diagnosis is essential because time from diagnosis to fasciotomy is the most important factor influencing outcome. A thorough decompression is essential to obtain a good clinical outcome and to prevent a catastrophic result⁷. There is no consensus on whether a release of both the anterior and posterior compartments should be performed when only one compartment is affected. We think that it is important to evaluate both compartments before and during the open procedure. If there is the slightest doubt, a release of both compartments needs to be performed.

References

1. Gourgiotis S, Villias C, Germanos S, Foukas A, Ridolfini MP. Acute limb compartment syndrome: a review. *J Surg Educ*, 2007, 64: 178–186.
2. Leversedge FJ, Moore TJ, Peterson BC, Seiler JG 3rd. Compartment syndrome of the upper extremity. *J Hand Surg Am*, 2011, 36: 544–559.
3. McQueen MM, Gaston P, Court-Brown CM. Acute compartment syndrome. Who is at risk? *J Bone Joint Surg Br*, 2000, 82: 200–203.
4. Mubarak SJ, Owen CA, Hargens AR, Garetto LP, Akeson WH. Acute compartment syndromes: diagnosis and treatment with the aid of the wick catheter. *J Bone Joint Surg Am*, 1978, 60: 1091–1095.
5. Matsen FA 3rd, Winquist RA, Krugmire RB Jr. Diagnosis and management of compartmental syndromes. *J Bone Joint Surg Am*, 1980, 62: 286–291.
6. Whitesides TE, Harada H, Morimoto K. Compartment syndromes and the role of fasciotomy, its parameters and techniques. *Instr Course Lect*, 1977, 26: 179–196.
7. Prasarn ML, Ouellette EA. Acute compartment syndrome of the upper extremity. *J Am Acad Orthop Surg*, 2011, 19: 49–58.
8. Hoover TJ, Siefert JA. Soft tissue complications of orthopedic emergencies. *Emerg Med Clin North Am*, 2000, 18: 115–139.
9. Jensen SL, Sandermann J. Compartment syndrome and fasciotomy in vascular surgery. A review of 57 cases. *Eur J Vasc Endovasc Surg*, 1997, 13: 48–53.
10. Fung DA, Frey S, Grossman RB. Rare case of upper arm compartment syndrome following biceps tendon rupture. *Orthopedics*, 2008, 31: 494.
11. McHale KA, Geissele A, Perlik PD. Compartment syndrome of the biceps brachii compartment following rupture of the long head of the biceps. *Orthopedics*, 1991, 14: 787–788.
12. Rafiq I, Anderson DJ. Acute rhabdomyolysis following acute compartment syndrome of upper arm. *J Coll Physicians Surg Pak*, 2006, 16: 734–735.
13. Ridings P, Gault D. Compartment syndrome of the arm. *J Hand Surg Br*, 1994, 19: 147–148.
14. Holland DL, Swenson WM, Tudor RB, Borge D. A compartment syndrome of the upper arm. A case report. *Am J Sports Med*, 1985, 13: 363–364.
15. Antebi A, Herscovici D Jr. Acute compartment syndrome of the upper arm: a report of 2 cases. *Am J Orthop*, 2005, 34: 498–500.
16. Diminick M, Shapiro G, Cornell C. Acute compartment syndrome of the triceps and deltoid. *J Orthop Trauma*, 1999, 13: 225–227.
17. Yabuki S, Kikuchi S. Dorsal compartment syndrome of the upper arm. A case report. *Clin Orthop Relat Res*, 1999, 366: 107–109.
18. Kim KC, Rhee KJ, Shin HD. Recurrent dorsal compartment syndrome of the upper arm after blunt trauma. *J Trauma*, 2008, 65: 1543–1546.
19. Cameron SE. Acute compartment syndrome of the triceps. A case report. *Acta Orthop Scand*, 1993, 64: 107–108.
20. Willsey DB, Peterfreund RA. Compartment syndrome of the upper arm after pressurized infiltration of intravenous fluid. *J Clin Anesth*, 1997, 9: 428–430.
21. Greene TL, Louis DS. Compartment syndrome of the arm—a complication of the pneumatic tourniquet. A case report. *J Bone Joint Surg Am*, 1983, 65: 270–273.
22. Sutin KM, Longaker MT, Wahlander S, Kasabian AK, Capan LM. Acute biceps compartment syndrome associated with the use of a noninvasive blood pressure monitor. *Anesth Analg*, 1996, 83: 1345–1346.
23. Gardner MJ, Flik KR, Dreese JC, Athanasian EA, Lyden JP. A traumatic compartment syndrome of the dorsal compartment of the upper arm. *Am J Orthop*, 2006, 35: 581–583.
24. Nixon RG, Brindley GW. Hemophilia presenting as compartment syndrome in the arm following venipuncture. A case report and review of the literature. *Clin Orthop Relat Res*, 1989, (244): 176–181.